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THE RELATIONSHIP BETWEEN MIGRATION AND DIAPAUSE DURING PHYLOGENY AND ONTOGENY OF SOME LEPIDOPTERA

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There are several opinions in the recent literature (Cayrol, 1965; Johnson, 1969 etc.) attempting to explain insect migration as an important ecological feature. It is concluded that migration is a phenomenon aiding the insect in escaping from temporarily unfavorable vital conditions: cold winters or hot, dry summers with the lack of food. The ecological importance of migration and especially its selective value are analogous to the phenomenon of diapause; during phylogeny, migration appeared as one of two possible methods of escape, or resistance, diapause being the other. Diapause or migration or both as escape mechanisms were fixed by natural selection under particular ecological conditions.

In recent papers, the relationship between diapause and migration was discussed as successive features typical for the whole population. For example: adults of some Ladybirds (Coccinellidae) migrate to hibernation quarters where proper imaginal hibernation starts (Hodek, 1962); the Bogong moth (Agrotis infusa Bsd.) migrates to mountainous areas where summer adult diapause commences (Common, 1954), etc.

So far no attempt has been made to explain the very significant evolutionary fact of when diapause and migration phenomena cause the split of a population at a certain point of ontogeny. Let us consider a species which produces a separate diapause, non-migratory population in one area, and, a non-diapause, migratory population in another area. Both populations hybridize in the zone of their occasional contact zone. The following summer generations separate, according to the genetic rules,

into original types, which have been influenced by natural selection of different seasons.

These problems have been investigated in Noctuid-moths (Lepidoptera). The synchronization of the development cycle of European Noctuidae with changing seasons is ensured by migration, or by diapause, or by both, in the necessary proportions. In the various species, differing ratios were found of diapausing individuals as compared with those migrating. Evidently the proportions of both these features change continuously among different species, but three or four groups can be defined:

1. *Species autochthonous in a certain area and having a well developed type of dormancy, usually a higher type of diapause.* Dormancy appears in one or more developmental stages. These species do not migrate across the frontiers of a particular climatic zone, or they do not migrate at all. They are distributed in the temperate and subarctic zone where the vegetation season is disconnected by a winter period. Most European Noctuids belong to this group, for example: *Scoliopteryx libatrix* L. (winter imaginal diapause), *Mamestra brassicae* L. (winter pupal diapause), *Amathes c-nigrum* L. (winter larval diapause), *Euxoa tritici* L. (winter oval diapause), *Eupsilia transversa* Hfn., *Conistra* spp. (winter imaginal and summer pupal diapause), *Rhyacia simulans* Hfn. (winter larval and summer imaginal diapause) etc.

2. *Species split into two partial populations: migrants and autochthons.* As to the proportion of diapause and migration phenomena, there are two classes:

a. The larger part of the population of an area is formed by a partial indigenous population and only a small part of the population is non-diapause of migratory origin. A good example is *Noctua pronuba* L.: Larvae of *N. pronuba* hibernate and then pupate in the spring. The adults emerge by the end of spring, the pupal stage being very short, and they undergo aestivation (summer diapause) which is induced by the photoperiod (long photophase). It was found that evidently all individuals undergo summer diapause (Novák and Spitzer, 1970). During the period of emerging and aestivation of the adults of this partial population, females with ripe ovaries sometimes appeared in Central Europe and laid fertilized eggs. These moths are probably of non-indigenous, migratory origin and come from ecologically different areas (Mediterranean). Some other *Noctua* spp. and perhaps *Scotia segetum* Schiff. belong to this category.

b. The largest part of a population of an area are migrants and only a small part of individuals forms a partial autochthonous population. A typical example is *Autographa gamma* L.: The partial autochthonous population hibernates as larvae of the 4th or lower instar which pupate in the spring. The migrants move to Central and Northern Europe from April to July, at the same time when indigenous adults appear. The partial populations — the migrants and the autochthons — partly hybridize and produce summer generations. Individuals genotypically conforming to the original migratory population move to the South in late summer and autumn. The others produce overwintering larvae within the limits of weather conditions (Novák, 1968). The relative proportions of the migrants and the autochthons vary from Southern to Northern Europe every year and perhaps orographically too.

3. *Non-diapause species which are not autochthonous, in Central and Northern Europe.* The populations of these lepidopterous insects renew by migrations every year. Examples of Noctuidae:
Scotia ipsilon Hfn., *Phlogophora meticulosa* L., *Heliothis peltigera* Schiff., *Autographa confusa* Steph. etc. Also some species of the families *Sphingidae, Pyralidae* and *Nymphalidae* belong to this group (Williams, 1958, Johnson, 1969). The adults of *S. ipsilon* Hfn. migrate to Central Europe from April to July, sometimes in several waves, and lay fertilized eggs immediately. The larval and pupal development is completed during the summer very rapidly without undergoing any kind of dormancy. The adults emerge in August and September having unripe ovaries — an initial or intermediate state of vitelogenesis. They do not lay eggs and their disappearance in October and November is explained by their migration to the South and partly by perishing in late autumn under severe seasonal conditions. Adult diapause (hibernation) seems to be improbable because of a non-diapause condition of the ovaries and of the fat reserves (Spitzer, 1969). The life history of *P. meticulosa* is similar, but the females of the summer generation sometimes lay eggs. The larvae perish later in the autumn and early winter as they are not able to hibernate.

4. In most tropical or subtropical oceanic countries (islands) with a uniform type of weather throughout the year and evergreen vegetation, only non-migratory and non-diapause insect species occur among real endemics — e.g. North Island of New Zealand (Spitzer, 1970).

In this paper, we have tried to show a simple and only preliminary ecological model of the relationship between insect migration and diapause, using our observations of Noctuidae. More autecological facts about single insect species and the investigation of the genetic mechanism of diapause and migration are needed.

REFERENCES

BROWN, E. S., BETTS, E., RAINEY, R. C. 1969, Seasonal changes in distribution of the African Armyworm, *Spodoptera exempta* (Wlk.) (Lep., Noctuidae) with special reference to Eastern Africa. *Bull. Ent. Res.* 58 (4): 661-728.

CAYROL, R. 1965, Relations existant entre les migrations et le cycle évolutif de certaines espéces de Noctuidae (Insectes Lep.). *C. r. Acad. Sci. Paris* D-260 (20): 5373-5375.

COMMON, I. F. B. 1954, A study of the ecology of the adult begong moth *Agrotis infusa* (Boisd.) (Noctuidae) with special reference to its behavior during migration and aestivation. *Austr. J. Zool.* 2(2): 223-263.

HODEK, I. 1960, Migration of Coccinelids to their hibernation quarters. *11th Int. Congr. Ent. Vienna* 1960 (3): 39-40.

JOHNSON, C. G. 1969, Migration and Dispersal of Insects by Flight. 763 pp., Methuen Co. Ltd., London.

NOVÁK, I. 1968, The hibernation of the Silver Y moth (*Autographa gamma* L., Noctuidae) under the climatic conditions of Central Europe. *13th Int. Congr. Ent., Moscow* 1968 (1): 533.

NOVÁK, I. and SPITZER, K. 1970, Unpublished data.

SPITZER, K. 1969, Some problems of the imaginal diapause in Noctuidae (Lep.). Thesis, 156 pp. (in Czech). *Czechoslovak Acad. Sci.*, Prague.

SPITZER, K. 1970, Observations on adult activity of Noctuidae (Lepidoptera) during winter in the Manawatu, N. Zealand. *N.Z. Jl. Sci.* 13 (2): 185-190.

WAY, M. J. 1962, Definition of Diapause. *Ann. appl. Biol.* 50: 595-596.

WILLIAMS, C. B. 1958, Insect Migration. The New Naturalist 36., Collins, London.